

---

# **Phenomenological Application of Target Theory Effects in SEE Analysis**

**Leif Scheick  
Section 514**

The research in this report was carried out by The Jet Propulsion Laboratory, California Institute of Technology, under a contract with National Aeronautics and Space Administration.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by the United States Government or the Jet Propulsion Laboratory, California Institute of Technology.

- **Complex biological cell systems and SEE vulnerable systems have similar traits**
- **SEE defined as atypical behavior in an irradiated system**
  - ◆ Microelectronic cells may upset from ion strike
  - ◆ Biological cells may die far earlier than predicted
- **Target theory describes events as a smooth function of radiation**
  - ◆ SEU and early cell death should not be defined well by target theory
- **Target Theory should be applied in a new way**

- **Target theory describes events in low LET environment**
  - ◆ Irradiation must be mostly continuous and have complete coverage
  - ◆ Cell or bit may not recover from radiation effect

$$\frac{dN}{dt} = -\frac{N}{C}$$

$$N_s = N_0 e^{-\frac{t}{C}}$$

$$N_d = N_0 \left( 1 - e^{-\frac{t}{C}} \right)$$

$$F_{tt}(t) = \left( 1 - e^{-\frac{t}{C}} \right)^D$$

- ◆ C and D determined partially by manufacturing parameters in microelectronics

- For high LET systems, target theory will have a different coverage function,  $g()$ 
  - ◆ Discontinuous irradiation and variable coverage
  - ◆ Target recovery and TID Effects
- Leading to:

$$F_{tt}(0) = \left( 1 - e^{-\frac{g(0)}{C}} \right)^D$$

$$g(\ ) = g(t, D, T, \theta)$$

- ◆ or even

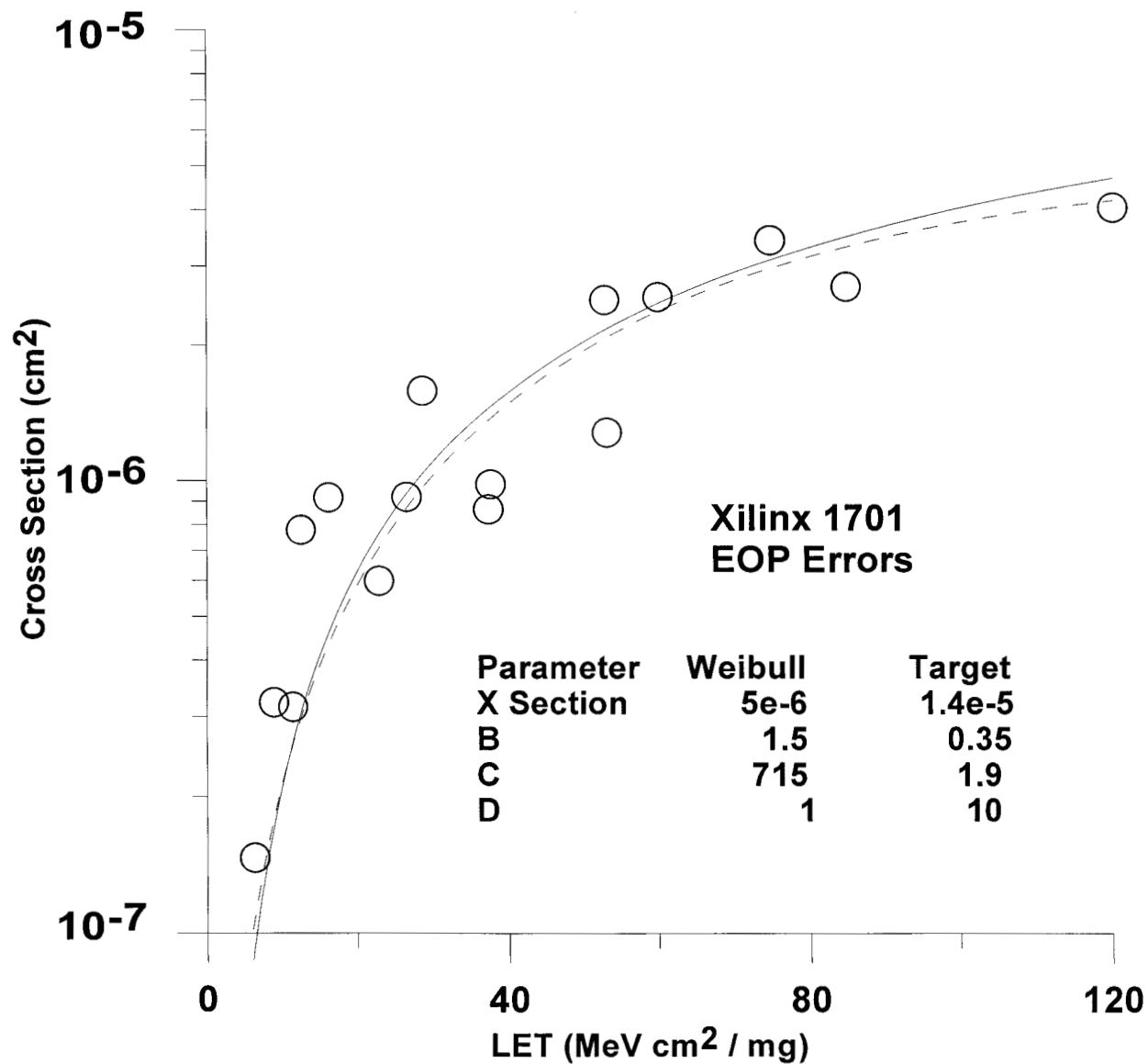
$$g(\ ) = g(t, D, T, \theta, LET) \qquad D = D(t, LET)$$

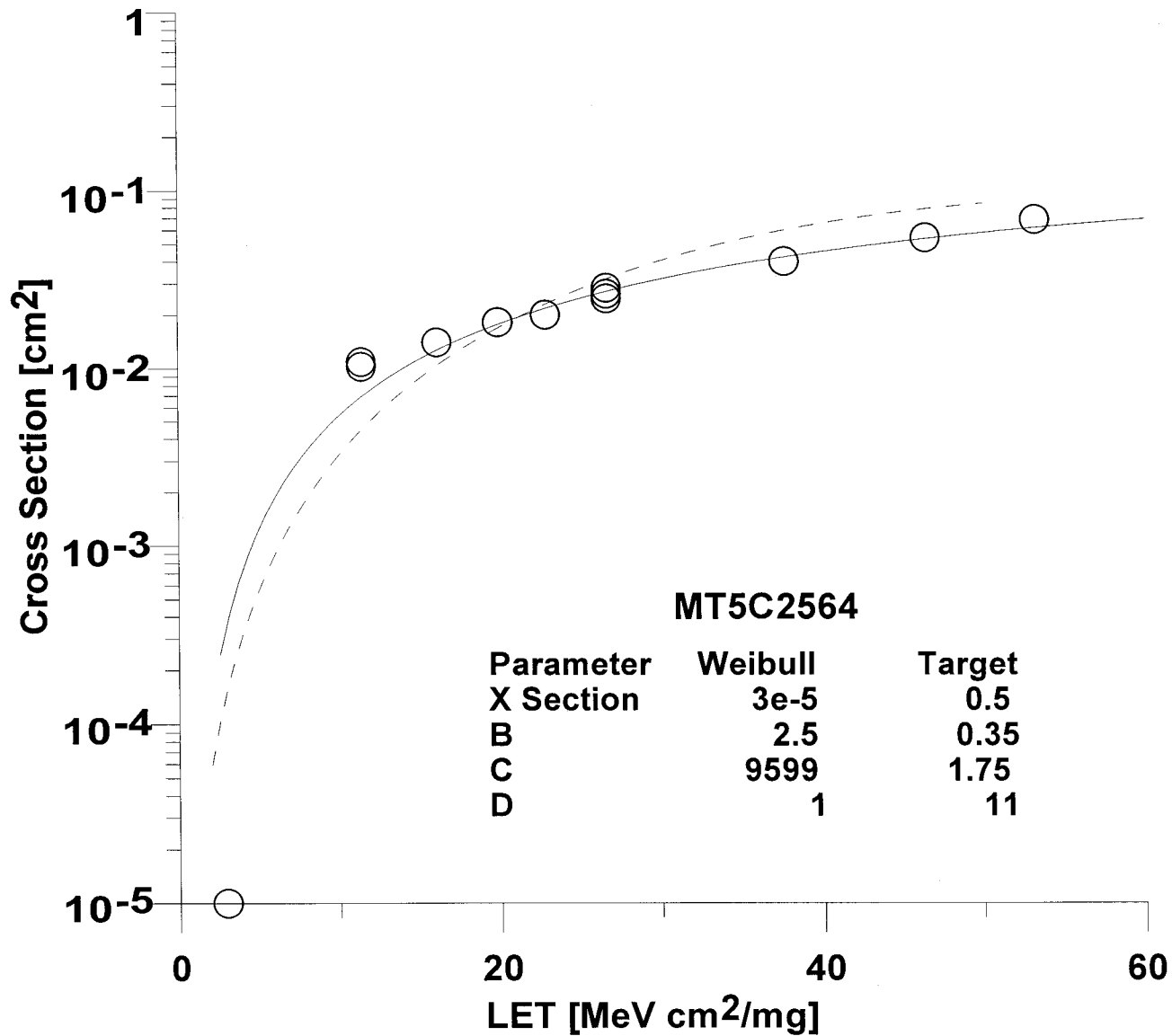
- **What could be the LET dependence?**
  - ◆ If LET and time are related, then the target theory analysis may explain SEU response.
  - ◆ Empirically, one can say that higher LET will have more effect:

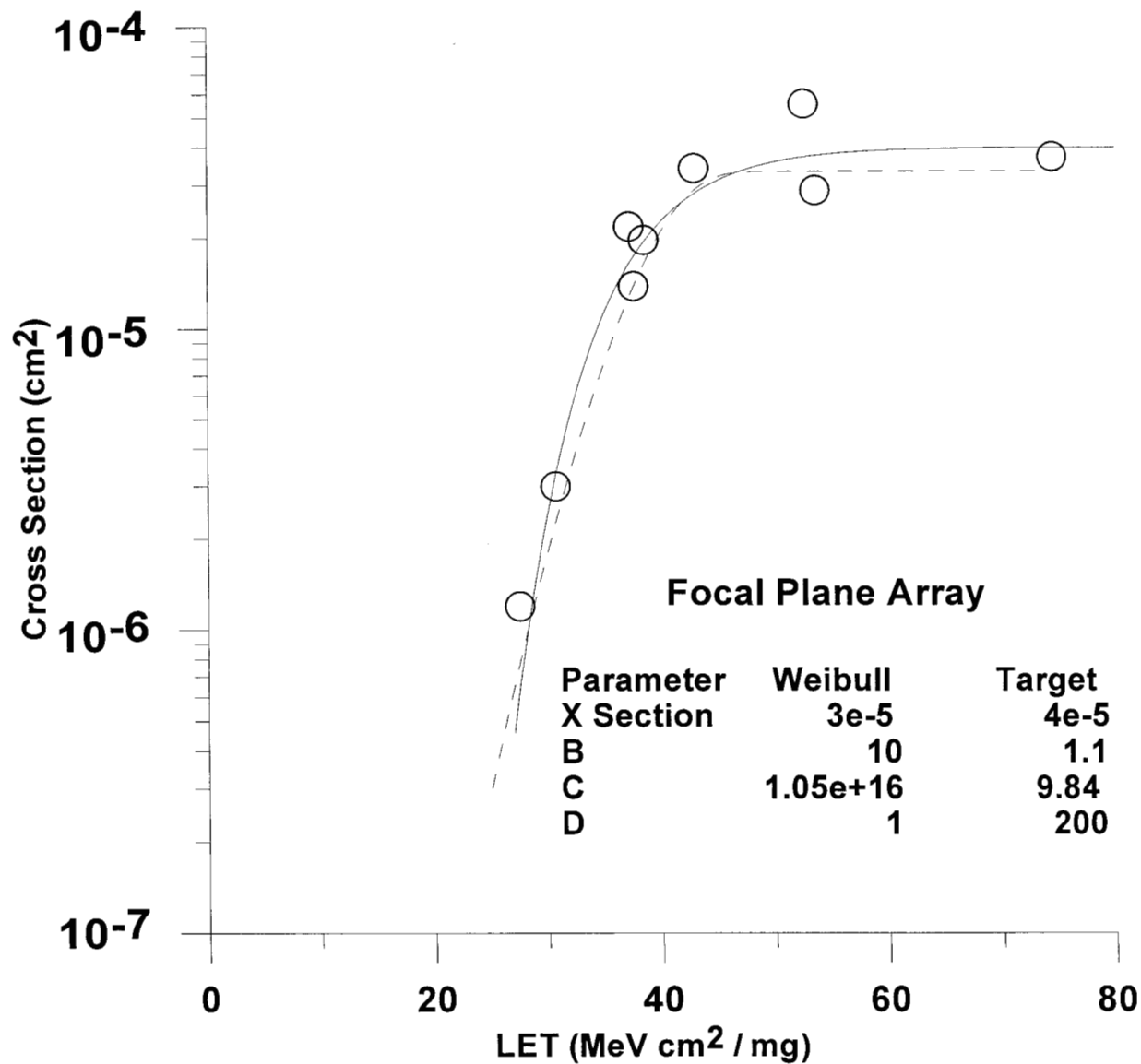
$$g(\ ) = LET^B$$

$$F_{tt}(LET) = \left( 1 - e^{-\frac{LET^B}{C}} \right)^D$$

- **Much like the Weibull Or Bendel Curves**







- **What do the parameters mean?**

- ◆ B is the Weibull shaping parameter
  - A production variable
- ◆ C is a hybrid parameter
  - is related to the LET threshold of the device
  - B and C together determine the behavior at low LET
- ◆ D is the target theory parameter
  - Determines the behavior at high LET
  - C and D together determine behavior at high LET
- ◆ Correlates to sensitive volume
  - Complex function of B, C, D

- **Exact distribution must be known**
  - ◆ High precision require for low LET SEU prediction
- **Knowing parameters of the distribution allows for prediction of threshold events**
  - ◆ Analyses like Extreme Value theory are vary dependent on distribution
- **Re-evaluate lifetimes of systems in inhomogeneous radiation environments**
  - ◆ Target theory can describe accrual of interface states as concurrently with SEE effects

- **Threshold LET may give valuable insight to SEU dynamics**
  - ◆ Extrapolation to radiobiological application
- **Statistics of Microeffects**
  - ◆ Threshold LET measurements should allow sensitive volume measurements
  - ◆ Using D to get number of targets, C to get target threshold and B to get target distribution should reveal sensitive volume structure

- **Target theory analysis highly dependent on probabilistic charge collection by SEU sensitive regions**
  - ◆ **Good Points**
    - Three degrees of freedom in fitting SEU cross section curves
    - Can be extrapolated to hybrid TIP/SEE studies
  - ◆ **Bad Points**
    - Parameters convolute in any kind of fitting procedure
    - Approximations made in derivation dilute parameters
    - Does not predict maximum cross section